Self-assembled molecular systems related to the origin of cellular life.

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An important question that must be answered if we are to understand life's origin fully is whether the living state arose a priori from pre-existing cellular structures. A feasible experimental approach to this question is to investigate laboratory models of primitive cells that can undergo growth and reproduction (1). To this end, we now know that certain amphiphilic molecules have physical and chemical properties that allow them to self-assemble into membranous structures. Such molecules and structures were presumably incorporated into primitive forms of cellular life. The following experimental results support this conjecture: 1. Bilayer membranes can assemble from a variety of simple amphiphilic compounds, including those present in carbonaceous meteorites. 2. Primitive cell membranes were likely to be composed of shorter chain lipids that provided access to external nutrients for macromolecules undergoing growth and replication in an encapsulated microenvironment. 3. Pigment systems and redox couples can be inserted into lipid bilayers and act to capture energy from sources in the local environment. 4. If dispersed lipids are mixed with macromolecules such as proteins or nucleic acids, then subjected to drying and wetting cycles to simulate a tide pool environment, the macromolecules are readily captured in membrane-bounded vesicles. 5. Vesicles composed of lipid bilayers can grow by addition of amphiphilic compounds present in the bulk phase medium. 6. Macromolecules such as RNA and proteins can be synthesized inside lipid vesicles by enzyme-catalyzed processes. The above results suggest that a laboratory version of an encapsulated system of molecules capable of growth, reproduction and perhaps evolution is achievable. The final challenge is to fabricate a molecule such as a ribozyme which incorporates both genetic information and polymerase activity, and is capable of self-replication in a membrane-bounded compartment. 1. Rasmussen S, Chen L, Deamer D, Krakauer DC, Packard NH, Stadler PF, Bedau MA. Evolution. Transitions from nonliving to living matter. Science. 2004 303:963-5.